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The Forum

Attractor States in Second Language Development

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Identifying changing patterns of stability and variability is crucial when examining second language development (SLD) from a complex dynamic systems theory (CDST) perspective (Larsen-Freeman, 2020). By studying attractor states, or recurrent patterns of stability, light can be shed on the underlying dynamics of a complex dynamic system (van Geert & Verspoor, 2015). In the context of SLD, attractor states can be observed in individuals' linguistic behaviors, as well as learners' interactions with others (Hiver, 2014; van Geert & Verspoor, 2015). As such, attractor states have been cited in recent SLD literature (e.g., Amerstorfer, 2020; Evans & Larsen-Freeman, 2020; Syed et al., 2021; Gillies & Roger, 2022). The conceptual unpacking of attractor states can therefore be invaluable for SLD scholars seeking to enter the realm of CDST. Accordingly, serving as a stepping stone for those looking to foray into the CDST paradigm, this forum piece offers a definition of attractor state, identifies and describes different types of attractor states, clarifies some possible misconceptions about attractor states, and provides a few examples of attractor states in SLD.

Put simply, *attractor state* refers to the state that a complex dynamic system (henceforth *system*) prefers to settle into (de Bot et al., 2007). That is, over time, the system tends to move towards particular "values, patterns, solutions, or outcomes" (Hiver, 2014, p. 21). The system falls into an attractor state due to its self-organizing dynamics, or in other words, the organization that emerges as a result of the interaction among the system's component parts, both with one another (internal to the system) and with components in the environment (external to the system) (van Geert & Verspoor, 2015).

Whether or not a system moves towards an attractor state is influenced by the feedback it receives. Such feedback can stem from inside or outside the system, and can be negative or positive. While negative feedback reduces the system's deviance from an attractor state, positive feedback can trigger instability and erraticism in the system's behavior (Hiver, 2014). In addition to positive feedback, a type of input known as a perturbation, an external force that can change the trajectory of a system (van Geert, 2008), can push a system out of an attractor state (Hiver, 2014). Though perturbations can move the system in a direction away from an attractor state, "the notion of attractor implies that the system will nevertheless try to keep its organization" (van Geert & Verspoor, 2015, p. 539). And, if the system is indeed perturbed, it will eventually return to the attractor state, except in the case where an external force successfully counters the system's tendency to settle into the attractor state (van Geert & Verspoor, 2015).

A system may settle into three distinct types of attractor states: fixed point, periodic (or limit-cycle), and strange (or chaotic). When a system recurrently settles into a single, unique point, then the attractor moves toward a fixed point attractor state (Hiver, 2014). This type of attractor state is the most predictable and stable (Tu, 2017). If a system cyclically moves between multiple points, then the attractor state is referred to as a periodic attractor state (Hiver, 2014). This type of attractor state takes place on a greater timescale and is less stable than a fixed point attractor state (Tu, 2017). Finally, if a system approaches multiple points over time but follows

an irregular, non-repeating pattern, then the attractor state is referred to as a strange attractor state (Larsen-Freeman, 1997; Hiver, 2014). Though the system's movement towards these points is unpredictable, the system's behavior is not totally random (Tu, 2017) and can be explained *a posteriori* (Hiver, 2014).

Before providing examples of attractor states in SLD, clarifications of some potential misconceptions about attractor states are in order. First, despite the word *attractor*, an attractor state does not exert an attractive or pulling force (Hiver, 2014). Rather, an attractor state refers to a point or pattern that a system tends to spontaneously move towards and actively sustain (Geveke et al., 2017). Second, an attractor state is not 'attractive' in the sense that it is desirable or favorable (Hiver, 2014). In fact, as is soon explicated, in the case of SLD, an attractor state can be an undesirable pattern from which a learner would prefer to and/or benefit from moving away. Third, it is important to distinguish between an attractor state and a variable, as these are often conflated (Hiver, 2014). Whereas an attractor state pertains to a system's behavior, including where the system tends to settle down, a variable traditionally refers to a condition or characteristic of an entity that can change (American Psychological Association, n.d.) or to an absolute outcome (Hiver, 2014). Clarifying these possible misconceptions may help some SLD scholars engage more deeply in SLD research guided by CDST.

The potential for studying attractor states in SLD is promising, as attractor states are relevant to learners' developing linguistic systems, to second language (L2) learners (as organisms), and to L2 learners' interactions. Some examples include the fossilization of L2 errors in a learner's interlanguage, the (un)willingness of a learner to communicate, and the behaviors of classmates in an L2 classroom. Fossilization, or the persistence of L2 errors in a learner's interlanguage despite favorable learning conditions (Han, 2004), can be viewed as an attractor state (Larsen-Freeman, 2005). For example, a learner's linguistic system may settle into L1-influenced patterns (de Bot et al., 2007). A learner's willingness to communicate in the L2, or lack thereof, can also be conceptualized as an attractor state (Syed et al., 2021). For instance, a given learner may repeatedly settle into an attractor state in which they do not voluntarily communicate in the L2, in spite of system-external components, such as the teacher, acting on the system. Lastly, at the classroom level, an attractor state might be a class of learners settling "into a pattern of supportive, inclusive and goal-oriented group learning behavior" (Hiver, 2014, p. 22).

In sum, examining attractor states is essential to understanding the dynamics of complex dynamic systems. The ubiquity of attractor states in SLD points to the utility of unpacking the notion of attractor state. This forum piece attempted to take a step in this direction by defining what an attractor state is, clarifying possible misconceptions about attractor states, and exploring a few attractor states in SLD.

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